Magnetic Resonance Imaging Needs Assessment

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Executive Summary

Introduction

The Province of Nova Scotia, through the Department of Health, has commissioned this study to explore the feasibility of rural MRI services in southwestern and northern Nova Scotia. This includes examining the possibility of a shared service agreement in these regions that is effective, functional and sustainable. Recognizing that with the introduction of any new technology or service, Canadians will need to compromise, as the health care system cannot be all things to all people.

Overview of Study

The primary purpose of this study is to conduct an extensive examination of the options for MRI service delivery models in rural Nova Scotia. This involved consultations with key subject matter experts in diagnostic imaging in New Brunswick, Nova Scotia and nationally. Based on the examination of submissions and the experience of the subject matter experts, key recommendations have been developed.

This study includes an overview of the current state of MRI service levels in Nova Scotia as well as comparisons to national levels. Rationales for recommendations are also provided.

Additional information, outside of the original scope of this study has also been included to enhance the understanding of the issues and the ensuing discussions.

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Magnetic Resonance Imaging Needs Assessment

Overview

The growing demand for MRI services in Nova Scotia has become a public, provider and Government concern. The Department of Health in Nova Scotia continues to be committed to providing the single best test for imaging diagnosis. Currently in 2004, the Province of Nova Scotia operates four publicly funded MRI machines serving a population of 950,000 people. Nova Scotia ranks approximately eighth in Canada in the diffusion of this technology. There are three publicly funded machines located in Halifax and a fourth in Sydney.

Two thirds of Nova Scotia's population is rural and current MRI access by road varies from one hour to four hours. There is an increasing demand for MRI services in Nova Scotia with a perceived and real under servicing of a large portion of the population. The province is committed to ensure that medical equipment, technology and human resources are available to provide service for all Nova Scotians and to support ongoing recruitment and retention of medical personnel in the rural setting.

As of February 2004, there were four operating MRIs in the Province of Nova Scotia. A 1.5 Tesla fixed site in Cape Breton was in the early stages of implementation. By national standards, it would be expected to perform approximately 3,500 scans per annum by the end of year two. Current data illustrates:

Currently Funded Public MRIs	
QEII	Siemens 1.5T (11 years old)
	GE 1.0T (8 years old)
IWK	GE 1.5T (2 years old)
Cape Breton	GE 1.5T (<1 year)

Volume of Services						
	QEII		**IWK**	**Cape Breton**	**Rural DHA**	**Rural DHA**
	Camp Hill	**VG**				
Hrs./Day	12	8	8	8	8	8
Days/Week	7	5	5	5	5	5
Vol./Week	120	70	40	40	40	40
Weeks of operation	50	50	50	50	50	50
Vol./Year	6,000	3,500	2,000	2,000	2,000	2,000
2006 Projection	6,000	3,500	2,000	3,500	3,500	3,500

The Canadian Association of Radiologists has recently revised their guidelines for MRI utilization. This includes current applications including MRA and Body MRI. A synopsis of their case volume recommendations includes suggested guidelines of 37 scans per 1000 population. The Province of Nova Scotia approaching a million population should have access to almost 35,000 scans for the entire province (950,000 people at 37 scans/1000= 35,000). As of 2002, Ontario and Alberta are at 27 and 28 scans /1000 respectively. Currently, 13,500 scans are provided, about 38% of national target. The current scan ratio is approximately 15 scans/1000.

MRI wait times available from data obtained from the Capital Health District are variable. Wait times vary from more than 200 working days (11 months) for an Orthopedic MRI and consistently range between 20-60 days (one to three months) for a Neuro MRI. The wait lists are understated due to limited access, particularly for rural Nova Scotians. They are in all likelihood significantly longer than those made available through the Capital Health District. In addition to the under servicing of MRI service, the technology at the QE II is dated, of low performance and has limited functionality with respect to magnet resonance angiography, magnetic resonance cholangiography, magnetic resonance venography as well as a number of other body MRI techniques. In addition, functional MRI and spectroscopy are limited at best. The chart below from the Fraser Institute, illustrates the average wait times in Canada.

Chart 6: Waiting for Technology—Weeks Waited to Receive Selected Diagnostic Tests in 2000-01, 2001-02, and 2003.

Province	CT-Scan			MRI			Ultrasound		
	2003	2001-02	2000-01	2003	2001-02	2000-01	2003	2001-02	2000-01
British Columbia	6.0	6.0	6.0	12.0	18.0	14.0	2.5	2.5	2.5
Alberta	6.0[1]	6.0	6.0	12.0[1]	8.0	12.0	2.8	3.0	2.5
Saskatchewan	6.8	8.0	8.0	20.0	14.0	16.0	2.0	2.0	2.0
Manitoba	7.0	6.0	5.0	10.0	9.0	8.0	8.0	10.0	8.0
Ontario	5.0	5.0	5.0	10.0	11.0	12.0	2.0	2.0	2.0
Quebec	6.0	4.5	4.0	15.0	13.5	12.0	6.0	4.0	4.0
New Brunswick	4.0	4.0	4.0	8.0	5.0	10.0	4.0	4.0	4.0
Nova Scotia	4.0	4.0	3.5	24.0	16.0	13.0	3.0	4.0	3.0
P.E.I.	8.0	6.0	10.3	12.0	12.0	12.0	6.0	9.0	6.0
Newfoundland	4.0	8.0	6.0	24.0	20.0	23.0	6.0	7.5	5.5
Canada	5.5	5.2	5.0	12.7	12.4	12.0	3.6	3.2	2.5

[1]Alberta Ministry of Health and Wellness website reports mean wait times for CT scans in the 6 to 93 day range (7 health regions reporting), and mean wait times for MRI scans in the 16 to 166 day range (6 health regions reporting) for the quarter ending December 31, 2002.

How the study was conducted

Background and administrative support was received from the Nova Scotia Department of Health, particularly through the office of Abe Almeda as well as Janet Knox and Cheryl Doiron. A number of meetings with department staff, members of the District Health Authority (DHA) medical staff and administration from the regions under study were conducted. Submissions and meetings were held with DHAs, numbers 1 through 7. Radiologists from the Capital Health District (DHA 9) and a supervisory technologist from Cape Breton (DHA 8) were also consulted.

Two groups bidding to provide private sector MRI in a publicly funded partnership, namely Insight Imaging Inc. and Canadian Diagnostics, had the opportunity to provide input into the study. Thanks to Dr. Bill Mason, Dr. Dan Reid, Dr. Derrick McPhee and Mr. Norman Goss for their interest and input.

Study Parameters

The parameters of the recommendations to the department are listed below. Note that additional parameters have been suggested to ensure a workable model as well as a number of discussions that ensued which are relevant to the discussion. They are listed in order of importance.

Original Parameters

- Critical mass of radiologists
- Building a sustainable service
- Shared service
- Geography
- Wait lists
- Population trend

Additional suggested parameters

- Emerging technologies
- Cost efficiency
- National standards and trends
- Physical plant

Relevant discussion topics

- Business case for fixed and mobile site technology.
- Practice Guidelines for family practitioners
- Review of existing MRI technology in the Capital Health District and Cape Breton
- Impact of PACS
- Public sector delivery versus private sector delivery

This report attempts to answer all relevant criteria for implementing a rural MRI program, designed for the unique needs of rural Nova Scotia. The author's perspective has been added with respect to existing MRI, future of CT, PACS and PET-CT. Major acquisitions such as MRI can not be made in isolation of the full needs of the province. The report and following recommendations are solely those of the consultant, Dr. Michael Barry, after extensive review and consultation.

In-depth Overview

The following sections provide detailed explanations of the examined areas and the basis for the recommendations.

The Private Sector

The first group, Insight Imaging Inc., offered to purchase, lease or operate one or two mobile MRIs in rural Nova Scotia. Their application is well thought out and reasonable and would certainly have provided some level of service beyond what is presently being offered. Public/Private partnerships are being encouraged in some areas of Canada. However, at this time, it is believed that the parties involved at the rural level were more likely to embrace a publicly funded high field fixed site installation in the northern and southern regions of the province.

The second group, Canadian Diagnostics, is a private sector organization that provides third party private access in a high field fixed site within Halifax. The service was credible, with well-trained MRI medical staff but could only provide an interim solution due to its geographic location.

The perspective of the private sector is encouraging, given the growth of public/private sector partnerships in healthcare being explored by a number of provinces in Canada.

Introduction of Rural MRI

DHAs 1, 2 and 3 from Southern Nova Scotia and DHAs 4, 5, 6 and 7 from Northern Nova Scotia all provided input for the study. Submissions and direct communication from DHA 9 or Capital District Health Authority were also reviewed as this region is the current major provider of MRI services in Nova Scotia, at least until Cape Breton is fully functional and implemented.

A critical mass of radiologists is vital to the development of an MRI service. There are a few sites that have a critical mass of radiologists, which would enable eventual implementation of an MRI program. This is the single most critically important criterion in the establishment of a program. It is only reasonable to place a service that is geographically accessible. Specialty care services are another criteria although of somewhat lesser importance than the first two. These criteria, along with current referral patterns and Department of Health District planning, round out the consultant's five major criteria for site selection. The organization of rural DHAs has not designated one particular rural DHA over another as most rural services are shared.

Population distribution is similar upon reviewing the demographics of the Province of Nova Scotia. Geographic distance was a minor issue for most sites as long as the service was centrally located into each of the regions. The only exception was that of Yarmouth which will be discussed separately.

The following numbers were taken from direct communication with each of the districts and hospitals in 2004.

Northern District Manpower:
- Antigonish – three radiologists, with a recruited fourth in 2006
- New Glasgow – two radiologists, with a potential for a third in the summer of 2005
- Truro – three radiologists
- Amherst – one radiologist

Southern District Manpower
- Bridgewater, four radiologists
- Kentville, five radiologists
- Yarmouth, four radiologists

Group 3 (DHA 4, 5, 6 and 7) and Group 4 (DHA 1, 2 and 3)

The two DHA groupings are remarkably similar in their challenges, both professionally and administratively. With essentially an equal distribution of population in a number of medium sized centers, the imaging services provided are quite remarkable given the difficulty in recruitment and retention. In its planning, the department has attempted to balance services among hospitals. Due to this planning, these districts have strong working relationships and are remarkably cooperative in their attempt to share service. The introduction of PACS has made the possibility of sharing imaging on call and clinical services significantly easier within the radiological community. The department is urged to expand PACS imaging throughout these regions in order to successfully implement a shared regional MRI program.

The groups have openly agreed to share any new MRI service. This is laudable and makes planning immeasurably easier.

Group 3, consisting of Amherst, Truro, New Glasgow and Antigonish, (DHA 4, 5, 6 and 7) serve a population of approximately 200,000. The leading contenders for MRI service, primarily because of critical mass of radiologists are Antigonish and New Glasgow. Although Truro has a critical mass, its close proximity to Halifax makes it a third candidate. New Glasgow does have an orthopedic service. New Glasgow currently has only two radiologists, one in his 60s and one in his 40s, neither of whom has any current MRI training. A third may arrive in July, 2005. This is something that the administration of New Glasgow should consider before the next phase of MRI technology evolves. Amherst is currently well served by Moncton and serves a significantly smaller population. Antigonish is the preferred site.

Rationale for Siting Decisions:

Antigonish, with a critical mass of three radiologists and a fourth expected to join the group in July 2006 is the preferred site over New Glasgow. This had significantly more weight over the two radiologists in New Glasgow, neither of whom is MRI trained. I would note that New Glasgow is expecting a third radiologist in the summer of 2005. Geography is a lesser factor in view of the fact that New Glasgow, within a radius of one hour, serves 525 communities and 113,000 residents. Antigonish, however, within one hour radius services 460 communities and 76,000 residents. These are only minor differences when compared with the difficulties encountered in Southern Nova Scotia with Yarmouth and the rest of the centers. The fact that Antigonish serves western Cape Breton, is in close proximity to New Glasgow and will receive some of the catchment from Truro makes it the number one recommended site.

A nucleus of two MRI trained radiologists in Antigonish (one about to train and soon to be a fourth) along with its specialty work in Internal Medicine, Ophthalmology and ENT make it well prepared for implementation of the service. Its geography is well positioned to serve Western Cape Breton as well as residents of the catchment of New Glasgow, Antigonish and to a lesser extent, Truro. Any patient receiving MRI service and investigation in Antigonish will travel less than an hour and a half for investigation. The only exception would be Amherst who would have to travel two and half-hours. Amherst is well served by Moncton and its relationship should be maintained.

Group 4 (DHA 1, 2 and 3), is comprised of Kentville, Bridgewater and Yarmouth (Digby is included in the Yarmouth district). Kentville indeed has a critical mass of five radiologists and is the choice for implementation of MRI technology. The only concern of the choice of Kentville is the service delivery to the population of Yarmouth. The establishment of an MRI service in Kentville improves capacity for the Southwestern Nova Scotia but does little to alleviate the geographic strain on those patients in Yarmouth. Yarmouth will be examined independent of this process in light of another option. Not only does Kentville have critical mass, with the exception of Yarmouth, it has central geography, a large population catchment and a number of sub-specialties including Orthopedics, Internal Medicine, Ophthalmology and ENT. Bridgewater has a critical mass of four radiologists, as does Yarmouth. Bridgewater endorses Kentville as the logical site for the next phase of MRI diffusion. This is provided that it is a shared service.

It is extremely important to understand the rationale for selection of Antigonish and Kentville as the preferred sites for the installation of 1.5T high field fixed site MRI. The critical mass of MRI radiologists and geography are heavily weighted in the selection process. These two hospitals indeed have the best case. New Glasgow certainly has a case for MRI implementation, particularly in view of an Orthopedics program as Orthopedics is a growing user of MRI technology. However, its lack of a critical mass of MRI radiologists heavily weighed in the decision. Its geography was an asset but in view of the information provided regarding Western Cape Breton, Antigonish was equal. Truro will certainly be worthy of MRI technology within the next five to seven years as it undergoes capital expansion and it is encouraged to prepare siting. It currently has a critical mass of radiologists although it would be somewhat redundant to place an MRI in Truro being slightly more than an hour away from Greater Halifax. Amherst might be the least likely site for MRI diffusion given its small population base but undoubtedly will acquire an MRI within the next 10 years as prices and operating costs reduce and applications increase. The only concern of placing an MRI in Kentville in Southwestern Nova Scotia is its three and a half-hour distance in servicing the southern tip of Nova Scotia, Yarmouth. Other than this, Kentville has a strong case for implementing an MRI program.

Yarmouth is the next site of preference for implementation of MRI due to its critical mass of radiologists and its geographic location. Bridgewater would likely acquire MRI technology before Amherst. The department should consider rolling out MRI technology similar to the way it successfully rolled out CT technology in the 1980s and 1990s.

Special Case for Yarmouth

The regional hospital in Yarmouth has a population catchment of 60,00 and a critical mass of four radiologists providing service to the southern tip of Nova Scotia. The geographic location being four hours from Halifax and three and half-hours from Kentville continues to be a challenge for the province to deliver services. Yarmouth Regional Hospital contributed through a submission by Dr. Eric Woods exploring the possibility of a low to mid-field open magnet. It is important to understand that lower field magnets can deliver quality imaging. The only limitation is signal to noise ratio in large patients. Throughput with the lower field strength magnet is less than that of a high field magnet. However, diagnostic quality for craniospinal and orthopedic MR is indeed superb. Most radiologists would not be able to discern the difference. In addition, lower field is able to deliver body MRI as well as some magnetic resonance angiography. The rationale for discussing the lower field is twofold; (1) lower capital cost (2) lower operating costs with the lower volume. Low or mid-field would fit the clinical caseload for such a center.

The Yarmouth Regional Hospital could receive a low to mid-field MRI and provide MRI within a not too distant timeline. In fact, it is possible that Yarmouth could begin to provide service for the southern tip of the province before Kentville has the opportunity to renovate and install a high field fixed site in their district. This would accomplish four things:

1. This would look after patients in the southern tip of the province, which for geographic reasons may be under serviced.
2. Increase provincial capacity and reduce workload in the other installed sites.
3. Allow the province to evaluate a different technology other than high field thus gaining some experience before the introduction of the next wave of MRI diffusion in small centers.
4. Allow Nova Scotia to move toward national recommendations.

The province should consider the option of trialing a low or mid-field magnet in Yarmouth, perhaps even during this phase of introduction of new technology.

Rollout				
July 1/2005	Kentville 1.5T	Antigonish 1.5T	••Yarmouth 0.3T – 0.7T	
July 1/2010	Truro 0.3T – 0.7T – 1.5T	Bridgewater 0.3T – 0.7T – 1.5T	New Glasgow 0.3T – 0.7T – 1.5T	•• Amherst

MRI Types Available			
Mobile (Superconductive)	0.5T	1.0T	1.5T
Fixed (Superconductive)	0.5T	1.0T	1.5T
Fixed Open (Resistive or Superconductive)	0.3T	0.37T	0.7T

The Program

Any new MRI program in rural Nova Scotia should be a shared service. There should be central booking and access for each of the DHA's population. The program must be run with a critical mass of MRI trained radiologists with an MRI Director, trained MRI technologists and educated clerical personnel. The complexity and safety in delivering an MRI program is unlike that in any other radiology imaging modality with the exception of Nuclear Medicine. The cooperative nature of the rural regions will make implementation significantly less complicated. A working committee should be immediately struck to review acquisition, installation and program development.

These rural MRI programs should not offer emergency service. Most of the MRI examinations will be craniospinal (80%) and orthopedics 15%). They will, however, be capable of providing magnetic resonance angiography for the investigation of stroke, hypertension and peripheral vascular disease. In addition, screening for Circle of Willis aneurysms and some limited body MRI applications will likely be necessary. There will be a short term discrepancy in that rural MRI centers will have better technology than the tertiary care centers in Halifax as they struggle to provide MRA, MRV and body MRI as well as a number of basic orthopedic applications. The department should not lose sight of the pressing need for upgrade and replacement in the Capital Health District.

MRI Technologist Certification

It is important for the DHAs involved in training to begin the process of MRI technologist certification. Enclosed in the Appendix are contacts for the educational programs across the country. Historically, in order to fully train an MRI technologist, it has taken upwards of one full year of MRI experience along with successful completion of a CMRT approved or CMA accredited Canadian MR Education program.

At the time of this writing, the policy may have changed and is certainly subject to provincial regulations. The local District Health Authorities involved in delivering the program should immediately explore these criteria through the implementation committee.

Usually, most sites utilizing these criteria have drawn from the CT technology pool and added personnel as needed. In order to begin the program, it is recommended that at least two MR technologists per site be trained initially with a plan to add a reasonable complement of trained CT and MR technologists to allow for holidays, vacations and illness. Further consultation with Dr. Barry is available with respect to this issue.

Technology of Choice

There was a review and discussion of the types of technologies that would be appropriate in any new rural MRI program. In particular, high field fixed site, mid-field fixed site, low field fixed site, mobile MRI and open magnet low to mid-field were all reviewed. Drawing on regional and national experience, the pros and cons of mobile versus fixed site service were examined. Although mobile does provide some geographic advantage, there is significant difficulty in establishing a complex imaging program when the technology is not fully embraced by a critical mass of MRI radiologists and technologists. This makes implementation of a fully functional MRI program extremely difficult and the magnet is likely to be under utilized. In addition, there are issues around siting, trucking, insurance as well as the state of the roads in rural Nova Scotia. Difficulties with winter weather are not uncommon with occasional leaking vans, faulty heating in sub-zero temperatures, air conditioning in hot weather and the overall poor work environment for MRI technologists. It was generally agreed that mobile is not the preferred option.

A high field fixed site was the preferred method of delivering this program. A fixed site enables a critical mass of radiologists to embrace this technology and fully develop its capabilities, not only in the neurological, head and neck, and orthopedic fields but also with body MRI, MRA, MRV as well as a number of other low volume roles that MRI provides. Two common examples include the occasional breast MRI for clarification of a mammogram and the occasional liver MRI for evaluation of hemangioma.

A conventional high field fixed site can be sited with appropriate shielding, connectivity, receiving and waiting room all in the vicinity of 2.6 million dollars. In addition, "uptime" is reported to be higher in a fixed site.

It is recommended that the province fund and operate each scanner eight hours a day, five days a week, booking 14 patients per day. Each scanner operating 50 weeks per year at 70 scans per week would provide up to 3500 scans on an annual basis. This would increase capacity up to 7,000 scans. This would bring the Province of Nova Scotia closer to the national average. Current data is changing in view of the rapid diffusion of MRI technology across the country.

It is important that PACS be implemented with the introduction of rural MRI. PACS is an imperative acquisition for any health care organization providing imaging services. Rural Nova Scotia lends itself to an integrated PACS program with broad band communication lines available from hospital to hospital. Not only will this ensure that the service is fully shared but complex cases can be reviewed in a multi-disciplinary fashion and tertiary care images can be easily transferred to the QEII or Cape Breton for higher level intervention. In addition, a regional and provincial on-call schedule will become a possibility.

Before implementation of the MRI program, an education program with practice guidelines should be presented to all primary care physicians referring patients in their respective regions. MRI is a mature technology, now in the armamentarium of primary care. Cost effective utilization can be attained with continuing medical education for the primary care physician. This would streamline and even reduce orthopedic and neurological referral, expedite decision making and alleviate significant patient pain and anxiety. The guideline included in this document's appendix should be used as a template to grow the indications.

Future Imaging Directions

MRI technology was the center of imaging development in the 1990s. Although MRI continues to serve a very important role and is clearly the imaging modality of choice in head and neck, craniospinal and orthopedics, it has a lesser role in body and vascular MRI. Mammography remains the mainstay in breast imaging. CT remains the mainstay in imaging of cancer of the chest, abdomen and pelvis. There is of course a blending of the technologies in certain disease processes, which enables staging and treatment to be improved in a complimentary fashion.

In the last five years, CT scanning has undergone a second revolution and has reasserted its role in the investigation of medical diseases. Multi-beam CT is currently replacing conventional angiography, (neuro and peripheral) investigation of hypertension and has now entered the investigation of coronary artery disease. MRI remains more precise for soft tissue detail. However, the speed and anatomic detail provided by multi-beam CT should not be lost on the stakeholders providing and making decisions in the implementation of new technologies. Another province wide upgrade to multi-beam CT is imminent. This will impact additional MRI acquisition in a budgetary fashion.

PET Imaging (Positron Emission Tomography) has become the next "big thing." The fusion of PET imaging with CT is something that the province should prepare for, particularly in the investigation, staging and ongoing treatment of cancer patients. The Province of Quebec is currently increasing its capacity of PET imaging with Alberta and British Columbia also looking to acquire PET-CT. The government of Ontario is currently studying the technology and this is felt to be a delay tactic due to the operating and capital costs of implementing such a program. New Brunswick is currently looking at the opportunity for PET-CT, as is the Capital Health District. Detail of PET-CT and its role is beyond the scope of this document. It will have a unique role in cancer and research.

Further Diffusion of MRI – "The Future"

The future of MRI diffusion in the public sector should be in two phases after the rural program is underway.

1. There is an urgent need to replace the aging two fixed site MRIs at the QEII and consider a third scanner.
2. Further diffusion of MRI technology through the Province of Nova Scotia in order of priorities should include:
   (a) Yarmouth
   (b) New Glasgow
   (c) Truro (making provisions for their planned expansion over the next five years)
   (d) Bridgewater
   (e) Amherst

It would be somewhat paradoxical for the highly skilled MRI radiologists in Halifax not to be able to provide advanced MRI imaging on behalf of their tertiary care patient population. With this expansion of rural MRI and state of the art technology, a significant number of exams will be capable of being provided in Antigonish or Kentville as well as Sydney but not in the QEII. Hopefully, this situation will be short-lived. It is important that the province understand the need for state of the art MRI imaging technology in Halifax to provide cardiovascular MRI, magnetic resonance angiography, body MRI, functional MRI as well as improved diagnostic accuracy in orthopedics, head and neck, body and craniospinal MRI. The QEII went through a

similar frustration during the introduction of CT where the rural areas were better outfitted with technology than was the medical center. This should not occur with appropriate planning.

Trialing a low or mid-field MRI (0.3T – 0.7T) may be the template for the next rollout of MRI technology for the sites mentioned above. Lower capital and operating costs would not compromise the quality necessary to deliver an elective MRI service. There are a number of low to mid-field scanners operating the USA providing outstanding quality and service. The only limitation may be spectroscopy or functional MRI. These are tertiary care tools.

One budgetary complication of a timeline to the rollout of MRI will be the upgrade to multi-beam CT. This may need to be reviewed before any additional MRI scanners are purchased. This should not impede this new rural program or the Halifax upgrade process.

Nova Scotia's National Ranking

The number of MRI scanners per population is an old standard. According to the most recent Canadian Association of Radiologists' data, Nova Scotia ranks eighth in the number of publicly funded functioning MRI scanners. There are currently four public scanners providing service to 950,000 people. This puts Nova Scotia with a ratio of one scanner to 235,000 people. New Brunswick, on the other hand, ranks first with one scanner for 150,000 people. Other authors compare diffusion to previous technology such as CT to MRI ratio. In Nova Scotia, the ratio of CT to MRI diffusion is 3.8:1, where in New Brunswick, its sister province is 1.8:1. Some authors believe the ratio should be even less than that of New Brunswick.

A more recent worldwide evaluation of MRI utilization is assessing the number of scans per thousand population. The Canadian Association of Radiologists in consultation with the Alberta Association of Radiologists endorses a national study, which was finished in April of 2002. This study reviewed the G7 countries and recommended 37 scans per thousand population. At the time of the study, Alberta was performing 28 scans per thousand while Ontario was performing 27 scans per thousand population. Nova Scotia currently provides approximately 13,500 scans per year. The Nova Scotia target with a population of 950,000 should be approximately 35,000 scans. Nova Scotia is providing approximately 14-15 scans per thousand population. The addition of two new fixed site scanners would raise this ratio but would still not nearly approach the target set by the Alberta study. Additional wait list targets have been targeted by the study which includes:

- Emergency studies performed within 24 hours
- Urgent studies performed within five days
- Elective studies performed within 30 days

These are indeed ambitious goals and targets but should be considered when determining any future imaging acquisitions.

Report Recommendations

1. The Province of Nova Scotia should acquire two high field fixed site 1.5 Tesla MRIs.
2. A high field fixed site 1.5 Tesla MRI should be installed at St. Martha's hospital in Antigonish, Nova Scotia.
3. A high field fixed site 1.5 Tesla MRI should be installed at the Valley Hospital in Kentville, Nova Scotia.
4. The province should concurrently pursue the development of PACS throughout the province, particularly in the northern and southern zones.
5. The service should be publicly funded.
6. The MRI program will be shared.
7. The province should consider acquiring a mid-field or low field magnet for Yarmouth due to its unique geography and in order to evaluate a lower cost technology in the next phase of MRI diffusion.
8. The province should procure these new MRIs on a combined basis in order to save on costs on acquisition, installation and service.
9. The MRI technology in the QEII is high priority and should be replaced beginning with the 11-year-old 1.5 Tesla Siemens, followed by the 1.0 Tesla GE MRI (eight years old).
10. The Province of Nova Scotia should consider targeting the recommended CAR guidelines of 37 scans per 1,000 population (35,000 scans per year)
11. The government should budget each new high field scanner to provide 14 scans per day, five days per week, 50 weeks per year for a total of 3,500 scans per year.
12. The government will be aware that MRI diffusion may follow CT and expect a third wave of MRI scanners may be necessary in the next five to ten years.
13. Practice Guidelines should be implemented to encourage access by family practitioners as well as specialists in coordination with an attending MRI radiologist.
14. The province should be aware of the impact of multi-beam CT and its effect on MRI utilization.
15. The province should be aware of PET-CT and its applications in cancer treatment and research and prepare for its implementation.

Appendix A: List of Meetings and Submissions

- Meeting of the Nova Scotia Department of Health and a Consultant in March 2004
- Meeting of consultant and representatives from DHA 1, 2 and 3 on April 14, 2004
- Meeting of DHA 4, 5, 6 and 7 on April 14, 2004
- Meeting of consultant and private sector vendor, Insight Imaging Inc., represented by Dr. Dan Reid and Dr. Bill Mason on April 14, 2004
- Meeting of consultant and private sector vendor, Canadian Diagnostics, represented by Mr. Norman Goss and Dr. Derrick McPhee
- Numerous conversations and e-mails with Department of Health consultant, Mr. Abe Almeda
- Consultation with Dr. Bob Abraham, QEII interventional radiologist
- Consultation with Dr. Rob Berry, QEII radiologist
- Consultation with Dr. Jamie Fraser, President of the Nova Scotia Association of Radiology
- Consultation with Dr. Daniel Hoffman, Chief radiologist, Aberdeen Hospital
- Consultation with Dr. Eric Woods, radiologist at Yarmouth Hospital
- Consultation with Dr. David Simms, former practicing radiologist at Valley Regional Hospital in Kentville, now relocated in New Brunswick
- Consultation with Dr. Arthur Marshall, Bridgewater radiologist
- Consultation with Mr. Glenn Gale, Administrative Director of Diagnostic Imaging, Atlantic Health Science Corporation
- Consultation with Canadian Association of Radiologists, Mr. Norman Laberge
- Consultation with Executive Director of the Ontario Association of Radiologists, Mr. Ray Foley
- Submission received from DHA 1, Bridgewater
- Submission received from DHA 2, Yarmouth
- Submission received from DHA 3, Valley Regional in Kentville
- Submission received from DHA 4, Truro
- Submission received from DHA 5, Amherst
- Submission received from DHA 6, New Glasgow
- Submission received from DHA 7, Antigonish
- Submission received from QEII with respect to volume, wait list and data on all three publicly funded Halifax MRIs, including IWK
- Consultation with supervising technologists at the Cape Breton Regional Hospital in Sydney

- Submission received and reviewed with data from the Nova Scotia Department of Health including orthopedic, medical manpower, MRI, provincial planning document and surgical volumes
- Submission from the Department of Health in Nova Scotia on recent article on "MRI and Family Practice."
- Submission of the Department of Health with geography and mileage of the regional hospitals in Nova Scotia
- Submission of the Department of Health with medical radiation technologist manpower in Nova Scotia
- Submission from Dr. Ron Johnson, St. Francis Xavier university
- Submission from Dr. Eric Howatt, Chief of Orthopedics at the Valley Regional Hospital in Kentville
- Consultation with Dr. Brian Nicholson, radiologist in Antigonish, August 2004
- Extensive review of CT/MRI needs assessment for the Province of Ontario, developed by the Ontario Association of Radiologists
- Review of the College and Physicians and Surgeons of Ontario Clinical Parameters and Facility Standards
- Review of the American College of Radiology Standards of Practice
- Review of Canadian Association of Radiologists Standards of Practice
- Personal file on multi-detector CT, PET CT Practice Guidelines, recommended case load per thousand population
- Review of MRI technology with existing vendors, GE, Siemens, Philips, Hitachi and Toshiba
- Review of the Romanow and Kirby Commission reports with respect to diagnostic access and wait lists
- Review of the Canadian Association election platform on wait lists and diagnostic imaging
- Consultation with GE Medical and national diffusion of CT (July 2004)
- Consultation with GE Medical with diffusion of multi-beam CT and its diffusion with particular attention paid to 16 slice, 64 slice and volumetric technology

Appendix B: Key Words and Definitions

MRI: Imaging technology using radio frequency coils acting on hydrogen atoms in the body within a strong magnetic environment

Tesla: Measurement of strength of magnets used in MRI. Diagnostic commercial MRI strengths vary from 0.35 to 1.5 Tesla traditionally. Higher field magnets of up to 3.0 Tesla are being installed for research purposes in some sites.

Fixed site: MRIs installed in hospital or imaging facility with shielding, wiring and the machine fixed to the floor.

Mobile MRI: A mid-field or high field magnet(0.5 Tesla, 1.0 Tesla or 1.5 Tesla) is installed in a transport truck/van and transported from site to site providing imaging services on an as need be basis.

High Field MRI: A 1.0 Tesla or higher

Mid-Field MRI: 0.5 Tesla

Low Field MRI: Less than 0.5 Tesla magnetic strength (0.3 Tesla or 0.37 Tesla)

Magnetic Resonance Angiography (MRA): Imaging of arteries using MRI technology

Magnetic Resonance Venography (MRV): Imaging of veins using MRI technology

Body MRI: Utilization of MRI for evaluating the neck, chest, abdomen and pelvis, breast as well as the limbs primarily for the investigation of tumor mass or infection

Cardiovascular MRI: MRI used in the investigation of cardiovascular disease particularly studies of the aortic arch, heart, pericardium and chambers.

Renal MRA: Magnetic Resonance Angiography evaluating the arteries supplying the kidneys in the investigation of hypertension.

Peripheral Vascular MRA: MRA used in the investigation of peripheral vascular disease in patients with arterial claudication or abdominal aortic aneurysm.

Functional MRI: Used in tertiary care services and research in evaluating brain function with location, research and mapping.

Spectroscopy: MRI used in evaluating protons in addition to hydrogen in order to characterize tumors or other lesions of the brain or body (Research).

Picture Archive Communication System (PACS): Imaging utilizing computers, high speed communication, and large digital storage all in an attempt to review, retrieve and send imaging information in digital format internally within hospitals or externally through the province and beyond.

Practice Guidelines: Guidelines used to help referring physicians in cost effective utilization of MRI or other new evolving technologies.

Open Magnet: An MRI where the imaging provided is not within a typical cylinder or bore but has a more open concept similar to a large four poster bed. These are traditionally low field (0.3) and now mid-field 0.7 GE.

Resistive Magnet: Traditionally a low field MRI using a different mechanism to acquire its magnetic field. Resistive magnets are generated by electricity and not by super conduction.

Positron Emission Tomography: An evolving and now clinically active imaging technology when combined with CT is the imaging modality of choice in many centers in diagnosing and following certain cancers along with cardiac and neurological indications

Multi-slice CT: New generation CT capturing multiple slices of image data simultaneously, increasing diagnostic speed and accuracy, and also enabling new applications for diagnosis.

Appendix C: Annual Cost and Operating Assumptions

Fixed Site MRI Costs and Benefits Discussion

Estimated Annual operating Costs

The following discussion is based on the actual operating costs of an MRI service using the New Brunswick (NB) experience but annualized to correspond to the Nova Scotia workload reporting model.

The data provided assumes an **annual patient volume of 3500 patients per site** (average of 14 examinations per day X 5 days per week X 50 weeks per year) at full production in year 2.

The data presented in Tables 1 and 2 are a per site operating cost again based on the New Brunswick experience and funding levels for full MRI service.

Cost excludes professional fees paid for interpretation of MRI images. These costs are billed to provincial medical insurance plan.

The one time setup costs in Table 1 include the design, siting, renovation, and electrical readiness for to receive the MRI unit at any one site.

Table 1 –Capital Acquisition Cost

High Field Strength – 1.0T to 3.0 T MRI	Cost
1.5 Tesla MRI Software and Hardware to support full clinical services	**$ 2.6 Million** * Budgetary pricing based on current market conditions from equipment vendor

Table 2 – One time Setup Costs

Item	Per site Cost
Renovations and Shielding *Assumes that existing space exists to house the MRI. New construction costs need to be estimated and added to this estimate.	$ 300,000

Table 3 – Monthly Operating Costs (1.5 T MRI)

Item	Monthly cost	Annual Cost
Salary & Benefits	16,500	198,000
Medical / Surgical supplies	750	9,000
Drugs and Medicines	5,500	66,000
Other supplies	1000	12,000
Item	**Monthly cost**	**Annual Cost**
Patient Comfort	100	1,200
Telecommunications	100	1,200
Education	200	2,400
Equipment Maintenance*	14,000	168,000
Small Equipment Purchase	200	2,400
Image Management	13,000	156,000
Miscellaneous	500	6,000
Total Annual Operating Cost		**$ 622,200**

Equipment Maintenance costs will vary with the size of the magnet. Generally, the service contract will vary (depending on the Service Level agreement) from 7 – 12% of the list price of the scanner.

Detailed definition of costs per site:

Salary and Benefits:
Includes two (2) FTE radiation technologists trained in MRI imaging, one (1) FTE clerical support, and one (1) FTE patient transporter ("porter").

Medical / Surgical Supplies:
Included in this category are items such as needles, dressings, swabs, bandages, gloves, etc.

Drugs and Medicines:
Included in this category are such items as IV solutions, vitamins and minerals, pharmaceutical agents, sedatives, medical gases, MRI contrast media, etc.

Other Supplies:
Included in this category are items such as office supplies, electrical supplies, etc.

Patient Comfort:
Included in this category are items such as ear plugs, audio relaxation products, visual aids, etc.

Telecommunications:
This category includes the costs of phone line, facsimile services, and data transmission.

Education:
This category includes books, training sessions, seminars, etc. to keep staff abreast of the MRI clinical application developments.

Equipment Maintenance:
This category is primarily for the service contract for the MRI unit for the routine preventative maintenance of the unit, cryogen recharging, magnet cooling "keeper" generator, etc.

Small Equipment Purchase:
This category includes any such items as computers, fax machines, telephones, or general equipment under $ 5000.00 used to support the MRI service.

Image Management:
This category includes cost of infrastructure to support the storage, transmission, display, and replication of the acquired MRI data sets. This can be commonly referred to as the "PACS" support (Picture Archive and Communication system)

Miscellaneous:
This would include any item not covered in the above categories.

Advantages of fixed site MRI imaging

- Provides MRI access to all clinical programs (Neurology, ENT, Orthopedic, Ophthalmology, Pediatric Oncology, Pediatrics, Endocrinology, and Pediatric Neurology)
- Maximizes funding for service (lower operating expense), can be as high as ½ the cost of mobile MRI.
- Tertiary care level hospital becomes able to provide the full emergency MRI service when the system is available all the time.
- Fixed MRI increases available scanning time to the site.
- Improved MRI access (fixed sites can provide 24 hour emergency call service for critical patients).
- Fixed site MRI can be installed in suites designed to provide appropriate support services to the critically ill patient, along with adequate space to effectively handle patient emergencies.
- Fixed site can provide patient support areas for patient holding, preparation, changing, monitoring etc.
- Controlled environment for ergonomics and comfort of patients and workers.
- Lower risk by having more ready access to clinical support services in the event of a patient adverse event.
- Reduced wait time intervals.
- Valuable recruitment and retention technology
- Superior image quality.
- Available funding dollars are directed to direct patient care, instead of non-patient costs such as transportation and truck maintenance.

The New Brunswick experience is that the fixed site MRI service is superior to a mobile service when viewed from the perspective scope and breadth of support to clinical programs. That is, the service concentrates on all clinical programs rather than the head and spine focus of a mobile MRI.

The other significant benefit is related to risk management of the patients in that the support of the "code" teams and other support physicians are more readily accessible to the MRI service. This can be critical during a patient adverse event in the MRI unit.

Low to Mid Field Open MRI: Costs and Benefits Discussion

Technology Discussion

Open Field MRI has become popular in centers that specialize in sports medicine, routine orthopedic, and some pediatric applications.

Open MRI technology has two distinct operating platforms for the magnetic field generation required to perform clinical MRI. These magnet technology platforms are:

Superconducting – whereby the magnetic field is created in the wire coils with an electric current flowing through the coils. To counteract the natural resistance in the wire, the coils are cooled to near absolute zero using cryogens. This allows a much higher magnetic field to be created using less current than the resistive type magnets. Maintenance of the cryogens is an added expense and procedure for the superconducting MRI systems. Cryogen cost was significant in early clinical MRI as the boil off rate required refilling the cryogen levels twice per year. However, the newer chiller units have extremely low boil off rates and require cryogen refills every 12 – 24 months. The result is dramatically lower operating costs in today high field magnets.

Resistive – whereby the magnetic filed is created by coiling wire around an iron core and passing continuous electrical current through the coils. This process requires large amounts of electrical power to operate, due to the resistance in the wire coils, and is limited to less 0.4 Tesla field strength due to the amount of energy consumed versus magnetic output when compared to the superconducting magnets. Resistive magnets are inefficient, meaning that there is much heat generated in the creation of the magnetic field and therefore requires constant water cooling during magnetism. It is widely accepted with today's technology, the efficiency in cost of operating a resistive magnet MRI is diminished at the 0.4 Tesla benchmark when comparing operating costs to a cryogen cooled MRI. Research is under way, in a joint venture with Siemens Electric and Oxford Magnet Technology, for the expansion of resistive magnet technology to increase to 0.6 Tesla.

The basic premise of an MRI is the larger the field strength, the greater the signal to noise ratio and thereby the better clinical dataset that is generated. This model if reflected in the type of clinical service that is provided at an imaging center and the clinical demand. Generally speaking, full clinical MRI is ideally suited to a 1.5 to 3.0 Tesla unit. MRI services from 0.3 to 1.0 see limitations in the types of procedures that can be performed due to the magnets ability to generate signal in large patients and fine detail needed for complex diagnostic interpretations.

Estimated Annual operating Costs

The following discussion is based on the actual operating costs of an MRI service using the New Brunswick (NB) experience.

The data provided assumes an **annual patient volume of 2250 patients per site** (average of 9 examinations per day X 5 days per week X 50 weeks per year).

The data presented in Tables 1, 2, and 3 are a per site operating cost again based on the New Brunswick experience, and funding levels for full MRI service, and market research for Open Field MRI scanners.

Cost excludes professional fees paid for interpretation of MRI images. These costs are billed to provincial medical insurance plan.

The one time setup costs in Table 1 include the design, siting, renovation, and electrical readiness for to receive the MRI unit at any one site.

Table 1 –Capital Acquisition Cost

Low to Mid Strength – 0.3T – 0.7 T	Cost
0.30 T Open Field MRI 0.70 T Open Field MRI Software and Hardware to support clinical Orthopedic and *limited* Neurological / Orthopedic service	$ 0.6 Million* $ 1.1 Million * * Budgetary pricing based on current market conditions from equipment vendors

Table 2 – One time Setup Costs

Item	Per site Cost
Site Preparation, Renovations and Shielding *Assumes that existing space exists to house the MRI. New construction costs need to be estimated and added to this estimate.	$40 - $80,000

Table 3 – Monthly Operating Costs
(based on 35% reduction in patient throughput)

Item	Monthly cost	Annual Cost
Salary & Benefits	16,500	198,000
Medical / Surgical supplies	750	5,760
Drugs and Medicines	3,520	42,240
Item	**Monthly cost**	**Annual Cost**
Other supplies	640	7,680
Patient Comfort	64	1,200
Telecommunications	100	1,200
Education	200	2,400
Equipment Maintenance	$10 - 14,000	$ 120 - 168,000
Small Equipment Purchase	200	2,400
Image Management	13,000	156,000
Miscellaneous	500	6,000
Total Annual Operating Cost **0.35 Tesla** **0.7 Tesla**		 **$ 542,880** **$ 583,200**

Detailed definition of costs per site:

Salary and Benefits:
Includes two (2) FTE radiation technologists trained in MRI imaging, one (1) FTE clerical support, and one (1) FTE patient transporter ("porter").

Medical / Surgical Supplies:
Included in this category are items such as needles, dressings, swabs, bandages, gloves, etc.

Drugs and Medicines:
Included in this category are such items as IV solutions, vitamins and minerals, pharmaceutical agents, sedatives, medical gases, MRI contrast media, etc.

Other Supplies:
Included in this category are items such as office supplies, electrical supplies, etc.

Patient Comfort:
Included in this category are items such as ear plugs, audio relaxation products, visual aids, etc.

Telecommunications:
This category includes the costs of phone line, facsimile services, and data transmission.

Education:
This category includes books, training sessions, seminars, etc. to keep staff abreast of the MRI clinical application developments.

Equipment Maintenance:
This category is primarily for the service contract for the MRI unit for the routine preventative maintenance of the unit, cryogen recharging, magnet cooling "keeper" generator, etc.

Small Equipment Purchase:
This category includes any such items as computers, fax machines, telephones, or general equipment under $ 5000.00 used to support the MRI service.

Image Management:
This category includes cost of infrastructure to support the storage, transmission, display, and replication of the acquired MRI datasets. This can be commonly referred to as the "PACS" support (Picture Archive and Communication system)

Miscellaneous:
This would include any item not covered in the above categories.

Advantages of open fixed site MRI imaging:

- Provides MRI access to clinical programs (Orthopedics, Pediatric Oncology, Pediatrics, Sports Medicine) *Other clinical applications are possible through the open configuration.*
- Reduced claustrophobia for patients
- Ability to perform dynamic – moving joint – studies ideally suited to Sports Medicine
- Open Field Fixed site MRI has all the same advantages of the fixed site MRI discussion
- Open Field provides better patient access during procedure meaning inpatients with monitoring or infusion equipment can be scanned without compromise
- Lower operating costs due to lesser or no cryogen use.

Disadvantages of open fixed site MRI imaging:

- Open Field MRI image quality may be compromised in larger patients (300 lbs +) due to the reduced signal to noise ratio of the lower field strength and lessened homogeneity of the magnetic field compared to a closed bore magnet. This translates into longer scan times to acquire a clinical diagnostic dataset.
- Patient throughput is reduced due to reduced magnetic field strength. The resultant reduction in patient throughput is factored at 35%.

Open Field MRI is suitable clinically for those centers where routine head and spine studies are the primary imaging focus. The units are designed with two goals; the first is to reduce rejected examinations due to claustrophobia, and the second, to provide acceptable clinical imaging for Neurology, ENT, Ophthalmology, and Orthopedic studies. An additional benefit of an open MRI system is dynamic or moving joint studies can be performed that are difficult to impossible in a closed bore MRI machine. Due to the comparative capital costs and the full clinical demand in Canada for an MRI installation, Open Field MRIs have not been popular in this country. However, in the U.S., where the demand can support specialized regions of interest in MRI

scanning, Open Field MRI has become popular in the orthopedic imaging centers or in imaging centers that focus purely on spinal and extremity MRI.

The literature suggests that absence of cryogen is low field MRI is a benefit. However, the added operational cost of electricity counteracts this potential saving. Low field strength MRI is appropriate where siting space and cost are of concern or if clinical practice is narrowly focused in head and spinal MRI. Based on experience these two regions compromise over 90% of routine clinical MRI studies. Therefore, when considering MRI siting in more rural areas that have little requirements for MR Angiography, MR Oncology, or research activities, Open Field Mid strength MRI is an excellent candidate for these communities. That is, capital expenditure costs and operating costs are maximized with no compromise to the clinical service delivery.

The discussions regarding advantages of resistive and superconducting magnets are best left to the physicists. Depending on preference for a particular technology, an argument may be made for one over another. What is evident from the literature, and most important in determining the clinical operating case, is that Open MRI technology has an application in rural Nova Scotia. Literature suggests the operational cost of MRI above 0.4 Tesla is the same in both technologies.

Therefore, the discussion has to be the right technology platform for the service area. Clinically, it is recommended that siting in the rural areas be Open MRI, 0.35 T to 0.7T, appropriate to support the services in thee communities. For example, Yarmouth is an ideal candidate for a 0.35T Open MRI to support the routine clinical in head, neck, and spine (craniospinal) studies. In the areas that require more clinical applications, approaching the 0.7 Tesla Open MRI may be more appropriate.

Mobile MRI: Costs and Benefits Discussion (Additional Information Purposes Only)

Estimated Annual Operating Costs

The following discussion is based on the actual operating costs of a mobile MRI service using the New Brunswick (NB) experience.

The data provided assumes an **annual patient volume of 3500 patients per site** (average of 14 examinations per day X 5 days per week X 50 weeks per year).

The experience is indicative of a mobile service between two sites over a total distance of 150 Kilometers. This is representative of the mobilization of the unit between Saint John and Moncton. Extrapolation of this data may be useful for the Nova Scotia model under consideration in this article.

Where possible, the costs presented are broken down into site specific costs. This will assist the reader to establish estimates in a two or more facility operation of a mobile service. Cost excludes professional fees paid for interpretation of MRI images. These costs are billed to provincial medical insurance plan

The one time setup costs in Table 1 include the design, siting, renovation, and electrical readiness for to receive the MRI unit at any one site.

Table 1 –Capital Acquisition Cost

Item	Cost
0.5 T MRI in Trailer 1.5 T MRI in Trailer • Software and Hardware to support clinical Cranial (head and Neck) and Orthopedic service • with generator power (to maintain magnet cooling)	~ 1.5 Million* ~ 2.5 Million * Budgetary pricing based on current market conditions from equipment vendors

Table 2 – One Time Setup Costs

Item	Per site Cost
Renovation	50,000
Docking station Pad	100,000
Electrical	30,000

Table 3 – Monthly Operating Costs

Item	Per site cost	# of sites	Monthly cost	Annual Cost
Salary & Benefits	16,500	2	33,000	396,000
Medical / Surgical supplies	1,500	2	3,000	36,000
Drugs and Medicines	5,000	2	10,000	120,000
Item	**Per site cost**	**# of sites**	**Monthly cost**	**Annual Cost**
Other supplies	900	2	1,800	21,600
Patient Comfort	100	2	200	2,400
Transportation (3 moves / wk)	8,500	1	8,500	102,000
Insurance	6,000	1	6,000	72,000
Telecommunications	100	2	200	2,400
Education	200	2	400	4,800
Equipment Maintenance	20,000	1	20,000	240,000
Small Equipment Purchase	200	2	400	4,800
Image Management	6,000	2	12,000	144,000
Miscellaneous	500	2	1,000	12,000
			Total Annual Operating Cost	**$ 1,158,600**

Detailed definition of costs per site:

Salary and Benefits:
Includes two (2) FTE radiation technologists trained in MRI imaging, one (1) FTE clerical support, and one (1) FTE patient transporter ("porter").

Medical / Surgical Supplies:
Included in this category are items such as needles, dressings, swabs, bandages, gloves, etc.

Drugs and Medicines:
Included in this category are such items as IV solutions, vitamins and minerals, pharmaceutical agents, sedatives, medical gases, MRI contrast media, etc.

Other Supplies:
Included in this category are items such as office supplies, electrical supplies, etc.

Patient Comfort:
Included in this category are items such as ear plugs, audio relaxation products, visual aids, etc.

Transportation:
Transportation costs of the contract for the mobilization and demobilization of the MRI unit, includes the cost of the tractor-trailer and driver. Insurance and liability are included in the contract costs with the service provider.

Insurance
Normally insurance would be included in the transportation cost. However, the increase in insurance premiums has required re-negotiation of the existing contracts where the rates can be the equal to the truck and driver costs. This is a major factor in considering the operation of an MRI unit that is mobile.

Telecommunications:
This category includes the costs of phone line, facsimile services, and data transmission.

Education:
This category includes books, training sessions, seminars, etc. to keep staff abreast of the MRI clinical application developments.

Equipment Maintenance:
This category is primarily for the service contract for the MRI unit for the routine preventative maintenance of the unit, cryogen recharging, magnet cooling "keeper" generator, etc.

Small Equipment Purchase:
This category includes any such items as computers, fax machines, telephones, or general equipment under $ 5000.00 used to support the MRI service.

Image Management:
This category includes cost of infrastructure to support the storage, transmission, display, and replication of the acquired MRI datasets. This can be commonly referred to as the "PACS" support (Picture Archive and Communication system)

Miscellaneous:
This would include any item not covered in the above categories.

The New Brunswick experience considers the advantages and disadvantages of the Mobile MRI service.

Advantages:

- Introduces clinical MRI to communities that otherwise would not be served
- Maximizes funding for service
- Improved patient care in Head and neck, ENT,Ophthalmology, and Orthopedics
- Elective Outpatient focused – addresses approx. 80% of patient population
- Supportive of Neurology and Orthopedic services

Disadvantages:

- Complex patient and inpatient scanning is not conducive due to physical proximity and physical space in the scanning areas.(e.g. patients requiring sedation, anesthesia for the procedure, or complex monitoring)
- Cannot support clinical service to programs other than Neurology and Orthopedics
- No access when MRI unit at other sites
- Limited procedure availability – only patients that require little or no nursing / physician supervision are referred to mobile MRI
- Patient care funding being spent on transportation cost (> $ 150K per year)
- Loss of scanner time at either site during the mobilization of the unit
- Field strength of magnet may be limited thereby reducing image quality.
- Susceptible to external forces, noise, and vibration that can affect image quality during patient scans.

The key to any clinical service is the consistent methodology or protocols used in the production of the clinical datasets. The New Brunswick initial model was designed with full duplication of the MRI technologists (those who operate and scan patients in the unit) at two sites. Experience has shown that these key resources (or at the very least two) should be allocated to the service across the sites providing MRI service. There is recognition that the mobility of these technologists with the unit provides the congruency for a stable and clinical sound service. In recent years, the introduction of two additional mobile routes in New Brunswick, 2.0 technologists are allocated to each service and are present during all scanning days. This is the preferred model for maximizing resources and providing clinical reproducibility.

Appendix D: Maps

NOVA SCOTIA
Health
District Health Authorities
With Hospital Locations

NOVA SCOTIA
Health
District Health Authorities
With Hospital Locations

Appendix E: Practice Guidelines for the Province of Nova Scotia's Rural MRI Program

Introduction

MRI technology is a mature and proven imaging modality for the investigation of a variety of illnesses, but particularly neurological, spinal and orthopedic. In addition, there is a growing list of applications in body and vascular MRI of which current technologies can address. Access to MRI at its introduction was traditionally a specialist tool. Today, however, limiting access to specialists only would be an impediment to patients. With appropriate practice guidelines, family practitioners can expedite diagnosis and treatment facilitated by appropriate specialist consultation.

The following guidelines are not intended to be complete but only to provide a template that would be built upon by the MRI radiologist and clinicians as they grow their imaging service.

Indications

Brain MRI: All of these diagnostic entities will have been investigated with at least an unenhanced CT and possibly a contrast enhanced CT before MRI approval by the attending MRI radiologist.

1. Demyelination
2. CVA (after investigation with CT for clarification)
3. Primary brain tumor
4. Brain metastases
5. Pituitary tumors
6. Orbital tumors
7. Posterior fossa masses
8. Acoustic neuroma
9. Skull based lesions
10. Hemorrhage

MRI Spine: All MRIs of the spine should be preceded by plain film review. Back or neck pain alone is not an indication for MRI.

Lumbar Spine MRI:

1. Spinal stenosis
2. Acute disc herniation with radiculopathy
3. Spinal block/metastases
4. Acute spinal compression fracture
5. Arachnoiditis
6. Introthecal spinal metastases
7. Discitis

Cervical MRI:

1. Spinal stenosis
2. Cervical Radiculopathy
3. Spinal cord tumor
4. Demyelination
5. Spinal compromise in light of wedge compression fracture
6. Discitis
7. Bone metastases

Thoracic MRI:

1. Spinal stenosis
2. Spinal cord tumor
3. Demyelination
4. Spinal metastases
5. Spinal canal narrowing secondary to wedge compression
6. Discitis
7. Bone metastases

Orthopedic MRI: MR arthrography should only be performed with a referral from an orthopedic surgeon.

Orthopedic/Shoulder:

1. Rotator cuff tear
2. Glenoid labral tear
3. Soft tissue mass
4. Shoulder impingement
5. Infection

Orthopedic/Knee:

1. Meniscal tear
2. Ligamentous tear
3. Osteochondral fracture
4. Baker's cyst
5. Anterior knee pain
6. Infection

Orthopedic/Miscellaneous:

1. Avascular necrosis - hip, scaphoid, lunate, etc.
2. Soft tissue tumors - (MFH, liposarcoma, lipoma, etc.
3. Occult fractures - hip, spine and scaphoid
4. Discitis
5. Bone metastases
6. Osteomyelitis
7. Brachial plexus injury

Body MRI & MRA: These studies should be done in consultation with an MRI radiologist and/or medical specialist.

MRA: renal artery stenosis, Circle of Willis aneurysm, cerebrovascular disease, abdominal aortic aneurysm, aortic arch aneurysm, dissection, and coarctation.

Body MRI:

1. Hepatic MRI - hemangioma versus metastases versus cystic change
2. Renal Mass - caval extension versus perinephric extension
3. Pelvic MRI - uterine and cervical carcinoma, fibroids, retroperitoneal neoplasm, pelvic neoplasm and perirectal cancer

Appendix F: Population per MRI Unit

Population Per MRI Unit

Province	Population	Ratio	Rank
BC	4,095,934	1:227,552	7
AB	3,064,249	1:153,212	2
SK	1,015,783	1:203,157	5
MN	1,150,034	1:287,509	10
ON	11,874,436	1:182,634	4
QC	7,410,504	1:211,729	6
NB	757,077	1:151,415	1
NS	942,691	1:235,672	8
PEI	160,000	1:160,000	3
NF	533,761	1:266,881	9

Appendix G: Population of DHAs by Gender

Population of DHAs by Gender Nova Scotia, 2003			
DHA	**Males**	**Females**	**Total**
DHA 1 (Lunenburg, Queens Counties)	29910	31054	60964
DHA 2 (Yarmouth, Digby Counties)	31587	32614	64201
DHA 3 (Annapolis, Kings Counties)	42711	43456	86167
DHA 4 (Colchester, East Hants Counties)	36561	36894	73455
DHA 5 (Cumberland County)	16102	16952	33054
DHA 6 (Pictou County)	24131	25215	49346
DHA 7 (Antigonish County)	24058	24317	48375
DHA 8 (Cape Breton) *	64437	68444	132881
DHA 9 (Halifax Regional Municipality) *	195667	202397	398064
Total for Nova Scotia	**465164**	**481343**	**946507**

* Site of present MRI units

Appendix H: About the Author

Dr. Michael Barry is a Dalhousie trained, New Brunswick practising radiologist. He has been in practice for 17 years, 11 of which he served as the Diagnostic Imaging Chairman at the largest hospital in New Brunswick, the Atlantic Health Sciences Corporation, and more specifically the Saint John Regional Hospital. This is a university appointment and the second largest teaching hospital in the Dalhousie Residency training program.

Dr. Barry has led the department through significant change in the 1990s including:

- Divisional Head of MRI 1995-2000
- Regionalization
- Co-chairing mobile MRI introduction for the Province of New Brunswick
- Author of Practice Guidelines for the initial MRI service in the Province of New Brunswick
- Transitioned mobile MRI to high field fixed site in MRI in Saint John
- Piloted first teleradiology project in Atlantic Canada
- Introduced and implemented PACS in AHSC leading to the eventual rollout of PACS technology to the Province of New Brunswick
- Led development of Diagnostic Imaging at the Atlantic Health Sciences Corporation growing from seven to 14 radiologists over 11 years and doubling the volume of services provided to the public.
- Led the department's involvement with the introduction of the NB Heart Center

Selected by university appointment as the departmental chair in February 1992 at the age of 35, Dr. Barry finished his second term in the summer of 2002 after the installation and implementation of the 1.5 fixed site MRI and twin CT suites at the Saint John Regional Hospital. The PACS program at this point was approximately 80% complete with outreach programs to seven hospitals in the region and on-call services to three regions in northern New Brunswick.

Currently, Dr. Barry is serving as Vice President of Medical Staff of AHSC, on the New Brunswick Medical Society Board, CMA General Council, and Saint John Board of Trade and is a frequent visiting speaker at the regional and national radiological and medical meetings.